SIZE SELECTION OF FOOD BY CUTTHROAT TROUT, *SALMO CLARKI*, IN AN IDAHO STREAM

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Abstract.— The mean size of food and amount of food consumed by cutthroat trout from Palisades Creek in southeastern Idaho increased with trout length. Number of organisms of terrestrial origin, number of aquatic larvae, number of ants, and number of berries from redstem dogwood were related to trout length. The size range and number of taxa consumed increased with trout size, indicating that as trout get larger, they broaden their feeding menu. The minimum size of food consumed was relatively constant for all trout, but larger trout appeared to feed more from the stream bottom. Trout may have a minimum length of food, below which items cannot be detected as food. Other possible factors affecting the feeding of cutthroat trout are mentioned.

Ecologists have been investigating the factors governing the feeding of stream trout for several years (Allan 1983). Trout have been assumed to be generalists or opportunists, feeding on invertebrates in relation to their abundance in the drift (Elliott 1973). One alternate hypothesis that has gained prominence is that of food selection by prey size. Prey size may work through reaction distance (Ware 1972, 1973), or merely through baseline availability, because a minimum length may exist below which trout cannot detect prey (Bisson 1978). The size hypothesis has been identified to play at least a partial role in the feeding of brown trout, *Salmo trutta* (Thomas 1964, Elliott 1967, Ringler 1979), eastern brook trout, *Salvelinus fontinalis* (Allan 1981), and rainbow trout, *Salmo gairdneri* (Bisson 1978). The objectives of the present study were to determine if food size selection by cutthroat trout occurs in a mountain stream in Idaho and if a linear relationship exists between the number of various food items in cutthroat trout stomachs and length of the trout. The hypotheses were that the mean length of food and abundance of food items in the stomach of a cutthroat trout will increase with trout length. The food habits of this species have not been extensively studied (Fleener 1952, McMasters 1970, Griffith 1974) even though this trout has a widespread distribution in the Intermountain West (Scott and Crossman 1973).

Study Area

Palisades Creek is a third order stream, draining the Palisades range of southeastern Idaho, and flowing into the South Fork of the Snake River. For late summer, maximum stream velocities of 100+ cm/sec, maximum depths of 1.5 m, and stream widths of 15 m are common. Riparian vegetation includes willows (*Salix* sp.), cottonwoods (*Populus* sp.), birch (*Betula* sp.), Douglas fir (*Pseudotseuga menziesii*), and lodgepole pine (*Pinus contorta*). In many areas of the stream, canyon walls extend to the stream margin, providing nearly continuous shading throughout the day, whereas other stretches flow through small meadows. Few typical pools exist, because riffle-runs, bank-runs and debris dams predominate.

Methods

Forty-eight cutthroat trout, ranging in length (head to tail fork) from 12.5 to 46 cm were collected by angling between 23 and 25 August 1983. Angling has been used by other researchers (Reed and Bear 1966, Hunt and Jones 1972, Tippets and Moyle 1978) and may be particularly well suited for high-gradient, fast-moving streams where collection by electroshocking is impaired. Trout length was measured at streamside, and stomachs were preserved in 70% ethyl alcohol for

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TABLE 1. Correlation analysis for the selected variables and fish length.

Variable	r	r^2	P	% occurrence
Total number prey	0.489	0.239	< 0.001	100
Number terrestrial	0.142	—	> 0.02	83
Number aquatic adults	0.377	0.142	< 0.005	73
Number aquatic larvae	0.027	—	> 0.50	100
Number C. stolonifera	0.241	—	> 0.05	50
Number E. doddsi	0.489	0.239	< 0.001	92
Number Formicidae	0.172	—	> 0.20	73
Mean length all food	0.381	0.145	< 0.005	—
Mean length aquatic larvae	0.472	0.223	< 0.001	—
Number taxa	0.342	0.117	< 0.01	—
Range of length	0.286	0.082	< 0.02	—

later analysis. All items in the stomachs were measured under a dissecting microscope and identified to the lowest taxonomic level practical (terrestrial animals other than Formicidae were lumped together, but most aquatic forms were taken to genus or species). To enable the use of correlation analysis, data were transformed to logarithmic scale prior to statistical analysis (Zar 1974).

RESULTS

Over 30 taxa, ranging in length from 2 to 70 mm, were recovered from stomachs of the 48 trout (see Appendix). The strong correlation for total number of prey and trout length (Table 1) suggests that overall food consumption is dependent on trout size. This is also true for consumption of *Ephemerella doddsi* larvae, the most frequently occurring aquatic insect larvae found in the stomachs of the cutthroat trout sampled. However, consumption of total number of organisms of terrestrial origin, number of berries from redstem dogwood (*Cornus stolonifera*), number of ants (Formicidae), and number of aquatic insect larvae were not related to trout size. Some of the berries from redstem dogwood did appear partially digested, indicating that trout may be gaining some nutritional value from them.

It is possible that correlation analysis was redundant for the number of ants and number of organisms of terrestrial origin and for the number of *E. doddsi* and number of aquatic insect larvae. Although no hidden relationship was detected for the ant component, the relationship between trout length and *E. doddsi* would have been missed had one relied solely on the aquatic larvae variable.

Mean length and the range of length (longest minus shortest) of aquatic insect larvae ingested by cutthroat trout were also related to trout length. As cutthroat trout from Palisades Creek grow, it appears that they rely on larger food, but still take smaller food items (Fig. 1). Cutthroat trout from Palisades Creek did not consume prey shorter than 2 mm, whereas almost 94% had a minimum prey length of at least 3 mm. With increasing trout length, the number of different food items increased. Apparently, as they grow, cutthroat trout in Palisades Creek do not shift entirely to larger prey or to a narrower range of taxa.

Since certain variables (e.g., number of aquatic larvae and number of organisms of terrestrial origin) were shown to be unrelated to trout length, one cannot automatically assume the positive relationships found for other variables and trout length are allometric, with the possible exception of total food item number. Since large prey were found in the stomachs of small trout, although infrequently, it is not possible to assume that the relationship between mean prey length and trout length is strictly a function of trout (mouth) size.

These observations are based on a small sample of trout, taken from only one season; consequently, it is difficult to extrapolate these findings to the same population during seasons having different benthic invertebrate abundances and diversities. More research into these variables appears warranted.

DISCUSSION

Prey size as a factor affecting the feeding of fish has been suggested for salmonids (Ware 1972) and strongly indicated in the

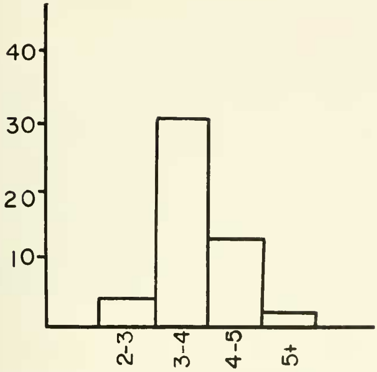

Fig. 1. Histogram of minimum lengths of food consumed and their frequency of occurrence in the 48 cutthroat trout stomachs sampled.

ecology of other fishes (e.g., *Lepomis* sp. in Werner and Hall 1974). Ware (1972), in laboratory experiments, has shown reaction distances by rainbow trout of lake origin to increase with increasing prey size. Ware (1973) included prey size in a model formed for predicting prey vulnerability to predation by rainbow trout, and he found the intensity of predation should closely parallel the change in prey size.

As shown, the mean length of food taken by cutthroat trout from Palisades Creek during the summer increased with trout length. Because small trout did have the ability to consume comparatively large prey, the question of why they don't take more of them arises. Smaller trout may spend too much energy in capturing, handling, and ingesting large food. If so, this would preclude them from taking great numbers of large prey, yet not entirely prevent an occasional large invertebrate from being taken. It may also be that trout are intimidated by large prey and avoid them. Large bodies may be representative of predators, and this may explain why there is a linear relationship between food size and trout size. A third possible cause could be social interaction within the trout population. Large trout may be dominant over smaller trout, enabling first choice of valuable food items (e.g., large prey) to be given to large individuals.

Ringler (1979) found brown trout in an artificial stream to consume small prey, even when larger prey were available. Increasing the size of prey and the assortment of prey types without reducing the range in prey length, as observed for cutthroat trout in the present study, may improve the energy gain for an individual fish. Overall energy expense should increase with body size; hence, large trout, especially drift feeders, would be at a disadvantage if they restricted their intake. Bisson (1978) postulates that smaller prey should at least repay the energy spent in their consumption by trout.

Prey lengths of about 2 mm have been suggested as minimum detection levels for rainbow trout, below which prey cannot be distinguished from other drifting material (Bisson 1978). The results of this study on cutthroat trout support this postulate. However, since lengths of members of the prey populations in Palisades Creek were not taken during the present study, it is difficult to speculate on the lowest possible lengths of invertebrates available. Benthic samples taken approximately two weeks earlier revealed large abundances of invertebrates of 1 to 3 mm sizes, indicating that smaller prey may have been present. This minimum length of detection hypothesis suggests that only prey larger than about 2 mm be used in estimating the available cutthroat trout food in a stream.

The strong correlation between the number of *E. doddsi* larvae and trout length is most interesting. This species is not a notable drifter in Palisades Creek (unpublished observations by author), and it may be possible that the majority of *E. doddsi* were taken from the stream bottom. If so, then as cutthroat trout get larger, they tend to feed more from the stream bottom than the drift. Tippets and Moyle (1979) observed a similar trend in the feeding of rainbow trout from the McCloud River, because larger trout contained food items more common to the benthos than the drift.

Simpson and Wallace (1978) suggest that terrestrial organisms form a major portion of the diets of cutthroat trout in Idaho. McMasters (1970) sampled cutthroat trout during July from a similar size stream in southeastern Idaho and found 33% to have fed upon terrestrial organisms. Of the trout sampled in the present study, 83% fed upon terrestrial organisms (Table 1). It is also interesting that so many trout (73%) had taken ants. Jenkins (1969) made use of marked ants in an experimental manipulation of drifting food and the feeding activities of rainbow and brown trout. The use of a prey organism in such manipulative studies should be predicated upon its natural occurrence in the diet of the fish being studied. Results from the present study indicate that ants are a common item in cutthroat trout diets; hence, adaptation of Jenkins's (1969) study to cutthroat trout should be feasible.

The occurrence of berries from redstem dogwood (*Cornus stolonifera*) in the cutthroat trout stomachs indicates an omnivorous trait of this species. Since half the trout sampled contained this food item, it seems easy to conclude that a generalist attitude exists toward feeding by cutthroat trout. However, optimal foraging theory (Krebs 1978) indicates that it may be more advantageous for trout to consume the vegetable than the invertebrate portion of their diet, depending upon caloric or nutrient value of the respective items and the energy spent in obtaining them. Since the number of berries from redstem dogwood apparently was not related to trout size, it is not reasonable to say that larger fish may benefit more than smaller fish by feeding on this item.

The data from the present study indicates that food size selection is occurring in a population of stream cutthroat trout. Size selection may be an important mechanism in the feeding of this species; however, it must be noted that, although the r values were significant—in some cases $p < 0.001$—the r^2 values were relatively low (0.145 for mean length of all prey and 0.222 for mean length of aquatic larvae). This suggests that other factors, possibly of equal importance, are operating on this interaction. For instance, Otto and Sjorstrom (1984) suggest morphology of stonefly larvae and the role of cerci and antennae in modifying their predator-prey relationship with first-year brown trout. Irvine and Northcotte (1984) observed rainbow trout fry in artificial stream channels to feed significantly more from groups of live *Simulium* sp. larvae than dead *Simulium* sp. larvae, a situation attributed to some invertebrate behavior that could not be exhibited by dead *Simulium* sp.. An interaction may also exist among prey size, morphology, and behavior.

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Appendix

Assortment of food items found in the stomachs of 48 cutthroat trout taken from Palisades Creek, Bonneville County, Idaho.

Ephemeroptera
- Baetidae
  - *Baetis* sp.
    - larvae and adult
- Siphlonuridae
  - *Ameletus* sp.
- Heptageniidae
  - *Epeorus* sp.
  - *Cinygmula* sp.
- Ephemerellidae
  - *Ephemerella coloradensis*
  - *E. doddsi*
    - larvae and emerging adults
  - *E. inermis*

Plecoptera
- Perlidae
  - *Acroneuria* sp.
- Perlodidae
  - *Megarcys* sp.
  - *Skwala* sp.
    - larvae and adult
- Nemouridae
  - *Zapada* sp.
- Chloroperlidae

Trichoptera
- Limnephilidae
  - *Neothremma* sp.
- Glossossomatidae
  - *Glossossoma* sp.
- Ryacophilidae
  - *Ryacophila* sp.
- Hydropsychidae
  - *Arctopsyche* sp.

Odonata
 Gomphidae

Diptera
 Tipulidae
  Antocha sp.
  Tipula sp.
  Dicranota sp.

 Simulidae
  larvae and pupae

 Chironomidae

Coleoptera
 Elmidae
  larvae and adult

 Dytiscidae

Terrestrial
 Formicidae
 Hymenoptera
 Diptera
 others

Terrestrial vegetation
 Cornus stolonifera

Fishes
 Cottidae
  Cottus bairdi

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